Amendments to the Drawings:

The attached sheet of drawings includes changes to Figure 2. In Figure 2, the fins referred to at page 5, line 9 of the specification have been shown schematically, as required, and designated by the reference numeral 9a.

Attachment: Replacement Sheet

REMARKS

In response to the objection to the drawings, as set forth at item 2 on page 2 of the Office Action, Applicants have submitted herewith a replacement sheet containing Figure 2, in which the fins (referred to at page 5, line 9 of the specification) have been shown schematically, and designated by the reference numeral 9a. Accordingly, reconsideration and withdrawal of this ground of objection are respectfully requested.

Claims 1-6, 8, and 9 have been objected to because they include multiple brackets around each reference numeral. In response to this ground of objection, Applicants note that the double brackets which surround the reference numerals in question were inserted by Preliminary Amendment, in order to show the deletion of those reference numerals in the manner provided in 37 CFR §1.121(b)(1)(ii). Accordingly, because these reference numerals were deleted in the previous amendment, they are not shown in the version of the claims set forth hereinabove.

Claims 1-9 have been rejected under 35 USC §102(b) as anticipated by Xu et al (U.S. Patent No. 5,918,470). However, for the reason set forth hereinafter, Applicants respectfully submit that all claims of record in this application, including new Claims 11-13, distinguish over Xu et al, and are allowable.

The present invention is directed to a cooling apparatus for a cryogenic system that includes a removable cryogenic refrigerator, and a thermal interface between the refrigerator

and an article that is to be cooled. In known cooling devices of this general type, a recondensing surface of the cryogenic refrigerator unit is provided in order to recondense evaporated cryogenic fluid and return it to a cryogenic vessel which houses a superconducting system, such as a magnetic resonance imaging device. In the latter systems, in which the recondensing surface is not exposed directly to the cryogen fluid in the cryogen vessel itself, there exists a requirement to provide an effective thermal interface between the refrigerator and the heat sink. (As discussed below, in the Xu et al patent, referred to in the Office Action, this thermal interface is provided by a compressible indium washer.)

With the foregoing refrigeration systems, problems are encountered when it becomes necessary to remove the refrigerator to maintain or replace it, in that the thermal coupling between the refrigerator and the heat sink may degrade. In particular, when the refrigerator is removed from the sleeve in which it is housed, the interior of the sleeve, and the refrigerated parts contained therein are exposed to atmospheric gases, so that it is difficult to prevent the latter from condensing or freezing on the inside of the sleeve. Although such condensate may be removed by bringing the temperature of the sleeve to the ambient level, such a procedure unduly lengthens the process for removal and replacement of the refrigerator, and may lead to unwanted losses of cryogen fluid. Further, the use of indium washers, as is the case in Xu et al, requires that a new such washer be utilized each time that the refrigerator is removed and replaced, which is also problematic.

The present invention addresses and resolves these issues by providing a thermal interface for conducting heat between a removable refrigerator and a heat exchanger that is in

thermal contact with the cryogen fluid of the article that is to be cooled, which interface consists of a recondensing chamber that is filled with a gas and is in thermal contact with a cooling surface of the refrigerator and with the article that is to be cooled. The thermal interface in this instance is a closed unit, so that the cryogen gas contained therein may be continuously liquefied by the transfer of heat to the cold head of the refrigerator, and boiled off by contact with the article that is to be cooled. In this manner, the thermal interface itself exists as a unit, so that it is easy to remove and replace the refrigerator as needed.

In accordance with the foregoing, Claim 1 defines a cooling apparatus which comprises a removable cryogenic refrigerator, and a thermal interface between the refrigerator and an article that is to be cooled. More particularly, and according to Claim 1, the thermal interface "consists of a gas held in thermal contact with a cooling surface of the refrigerator, within a closed recondensing chamber". The article is then cooled by thermal conduction through a wall of the closed recondensing chamber.

The Xu et al reference, on the other hand, discloses a recondensing zero boiloff superconducting magnet assembly which uses a cryocooler with a compressible indium gasket positioned between the cryocooler and the recondenser. More particular, as illustrated in Figure 1, the Xu et al system includes a two-stage cyro-cooler 12 having a cold head 30, which is positioned within a sleeve so as to contact a thermal interface gasket 29. (See Column 2, lines 46-50.) The indium gasket, in turn, is in direct physical and thermal contact with a heat sink 11 of a recondenser 39, as indicated in the specification at page 3, lines 9-13. Cyrogenic fluid 5 from a pressure vessel 4 circulates via lines 50 and 54 between the interior

of the pressure vessel and a recondensing chamber 38. In this manner, thermal communication between the cold head 29 of the two-stage cryocooler 12 and the circulated cryogen fluid in the recondensing chamber 38 and the heat transfer plates 42 of the recondenser 39 is provided by the direct physical contact of the cold head 30 with the indium gasket 29, which in turn is in contact with the heat sink 11 of the recondenser 39.

As can be seen from the foregoing brief description, the Xu et al apparatus does not include a thermal interface that "consists of a gas held in thermal contact with a cooling surface of the refrigerator, within an enclosed recondensing chamber". In this regard, Applicants note that the rejection of Claims 1-9 in item 5 of the Office Action based on Xu et al is premised on the proposition that the interior 32 of the cryocooler sleeve assembly 8, 18, 23 in Xu et al constitutes a "recondensing chamber". In response to this observation, however, Applicants respectfully submit that the "interior" or the "cavity" 32 of the sleeve assembly 8, 18, 23 does not constitute a recondenser chamber, and is incapable of performing as such. Moreover, it also true that any "gas" which might incidentally be contained therein, does not provide a thermal interface between the cold head 30 and the article that is to be cooled (being the cryogen fluid 5 contained in the pressure vessel 4). Rather, as noted previously, the thermal interface between the cold head 30 and the cryogen fluid is provided by direct contact of the cold head with the indium gasket 29, which in turn directly contacts the heat sink 11. Thus, heat transfer between the recondensing chamber 38 and the cold head is achieved by a flow of heat directly from the cooling plates 42, through the heat sink 11 and the indium gasket 29 to the cold head.

The Office Action also notes in this regard that Xu et al discloses that trapped gases contained in the thermal interface gasket will escape into the cavity 32 once the refrigerator has been installed, referring in particular to Column 4, lines 21-26. With regard to this observation, Applicants note that insofar as the disclosure in Xu et al is concerned, the presence of any gas which may escape into the cavity 32 during the assembly process is incidental to the operation of the system. Indeed, the interior 32 of the cryocooler sleeve is mentioned in the specification only twice in passing (at Column 2, lines 56 and 61) and Xu et al contains no discussion which teaches or suggests that it constitutes a recondensing chamber, or a thermal interface, or that it is capable of doing so. Indeed, it is apparent from the disclosure that it is not. Moreover, Applicants respectfully submit in this regard that the term "recondensing chamber" is a widely understood term of art, which refers to a vessel in which a previously evaporated liquid is recondensed back to a liquid form, and that term is used consistently throughout not only the present application, but also the Xu et al reference itself. (See, for example, Xu et al, Column 1, lines 31-38 and Column 3, lines 22-34.)

Independent Claim 8, on the other hand, defines a thermal interface which comprises "a closed recondensing chamber" that is in thermal contact with a component that is to be cooled. In addition, Claim 8 specifies that the recondensing chamber "is filled with a gas which is recondensed into a liquid by the recondensing refrigerator, whereby thermal contact between the recondensing refrigerator and the component is provided by recondensation of the gas and through the wall of the closed recondensing chamber". The latter features of the present invention are also not found or suggested in Xu et al. In particular, the interior 32 of

the cryocooler sleeve assembly is not "filled with a gas which is recondensed into a liquid by the recondensing refrigerator".

New Claim 11 includes all of the limitations discussed previously with regard to Claim 1. In particular, the last paragraph of Claim 11 recites that the recondensing chamber is so configured that, in an operating state, "gas that is liquefied in said recondensing chamber accumulates adjacent" a wall that is in thermal contact with cryogen fluid in an article to be cooled, "and is boiled off by heat transferred from gaseous cryogen fluid in said article that is to be cooled". The latter features of the invention also are not taught or suggested by Xu et al for the same reasons discussed above.

Finally, Claim 12 also includes the features of Claim 1, but further specifies that the cryogenic cooling apparatus includes both a first recondensing chamber that is in thermal contact with a cooling component of a cryogenic refrigerator, and a second recondensing chamber that is in thermal contact with the first recondensing chamber and with an article that is to be cooled. In addition, Claim 12 recites that the first recondensing chamber is separated from the second recondensing chamber by a common structural component that forms a heat transfer path between the first and second recondensing chambers, and seals and isolates the first recondensing chamber from the second recondensing chamber. As noted previously, however, the Xu et al reference contains only a single recondensing chamber 38 (and a recondenser 39 situated therein). Accordingly, it does not provide a cryogenic cooling apparatus which includes both first and second recondensing chambers, such as defined in Claim 12.

In light of the foregoing amendments and remarks, this application should be in condition for allowance, and early passage of this case to issue is respectfully requested. If there are any questions regarding this response or the application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323, Docket No. 038817.58287US.

Respectfully submitted,

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Attachments: Replacement Sheet (Figure 2)
Substitute Specification and marked up version thereof